Workarounds Used by Nurses to Overcome Design Constraints of Electronic Health Records

Sarah A. Collins, RN, PhD[1], Matthew Fred, MD[2],
Lauren Wilcox, MS, PhD(c) [2], David K. Vawdrey, PhD[2]
[1]Partners HealthCare, Wellesley, MA, USA; [2]Columbia University, New York, NY, USA

Abstract

Adoption of electronic health records (EHRs) has the potential to assist with clinical reasoning and streamline workflow; however, the data entry and review capabilities of most systems are suboptimal which may lead to workarounds. As an instance of a workaround, we examined nurses' use of optional free-text comments in EHR flowsheets to support clinical needs for data interpretation. This mixed-method study included: 1) Content analysis of comments, 2) Interviews with nurses. We performed a sub-analysis of flowsheet data for 201 patients that experienced a cardiac arrest and interviewed 5 acute care nurses. We found that nurses used workarounds in the EHR - despite the extra effort that they required - to convey clinically significant relationships and to communicate concerning events to physicians. EHRs should better support entry of clinical data that "belongs together" and enable messaging capabilities integrated with nurses' flowsheet documentation workflow.

Introduction

In the United States, Meaningful Use of Health Information Technology requires that providers and organizations collect accurate, complete data from their patients and summarize those data to demonstrate effective use of the electronic health record (EHR).[1] Several studies report that clinicians spend up to 30% of their work-day performing documentation tasks[2,3]; yet, the quality of data in EHRs is suboptimal, inefficient for information retrieval, and may lead to information overload.[1,4,5] Our prior work found that nurses' increased documentation of optional free-text comments in EHR flowsheets are associated with the abnormality of vital signs and survival outcomes of cardiac arrest patients.[6] These findings indicate the potential of EHR data as a knowledge source to be mined. The redesign of EHR data views may allow clinicians to harness such knowledge to support decision making at the point of care.[6]

In paper records, physiological measurements (e.g., vital signs) and treatment parameters (e.g., medications given, oxygen administered) are entered on paper flowsheets that have time-stamped columns. The data entry medium doubles as the medium for data review on paper. Nurses routinely write comments in the margins or other white space of the paper flowsheet to provide clinical context for recorded measurements or to record interventions.

Typically, EHR flowsheets, such as the one used at our study site, are similar in design to the paper record. However, in electronic form, data entry of vital signs, respiratory parameters, and administered medications is distributed across multiple screens. This fragmentation presumably exists to minimize scrolling and enable spatial organization of similar types of data. However, the use of separate entry screens creates challenges for nurses recording data, and even greater challenges for clinicians reviewing data. As in a paper chart, nurses can annotate flowsheet entries with free-text comments. However, these comments are not visible by default (a non-descript icon alerts the user to their presence), and may be scattered across multiple flowsheets. Finding these comments can prove non-intuitive and time-consuming for the clinician. Furthermore, a mismatch between the perceived purpose, content, and intent of clinical documentation may decrease the likelihood that a message is communicated as it was intended.[7]

The adoption of EHRs may streamline clinician workflow, yet, anecdotal reports from clinicians practicing at our study site suggest that data entry and review tasks in the EHR are unnecessarily complicated and inefficient. Given nurses' already have a high workload, we suspect that nurses that opt to documentation above and beyond what is required perceived that data to be clinically significant. Therefore, we conducted this study to examine nurses' use and perceived clinical significance of optional comments within EHR flowsheets.

Methods

The study was performed at a large urban medical center that has used a commercial EHR since 2005. Users may enter a free-text comment associated with a structured data field within the EHR flowsheet. Entering or viewing a comment required the user to right-click and select the 'Edit comment field' option. A small asterisk in the upper right hand corner of a structured field indicated that a comment had been entered.

This was a mixed-method study including: 1) Sub-analysis of the content of nurses' optional documentation in EHR flowsheets, 2) Semi-structured interviews with acute care nurses to understand their use of optional documentation in EHR flowsheets. Content analysis was performed for comments associated with three clinical scenarios. Institutional Review Board approval was obtained prior to all data collection for this study.

Content Analysis

We performed a sub-analysis of EHR flowsheet data for three clinical scenarios using a data set of hospitalized patients that experienced a cardiac arrest over 16 months. The scenarios were evidence-based clinical relationships that consisted of a physiological measurement and an associated intervention: 1) Oxygen level: supplemental oxygen administered, 2) Blood sugar: insulin or sugar source administered, 3) Blood pressure: blood pressure medication or intravenous fluid administered. For example, to treat a high blood sugar, insulin should be administered. Within our EHR, the measurement and intervention are documented in structured fields on separate flowsheets, yet, these data are dependent on each other for an accurate evaluation of the patient's clinical state.

We coded flowsheet comments using our previously published categorization of flowsheet comments: *intervention, physician/nurse practitioner/physician's assistant (MD/NP/PA) was aware of the measurement, assessment, equipment information, plan, reference to other shift or location, registered nurse (RN) aware of the measurement, and reference to other documentation.*[6] Inter-coder reliability was performed on 10% of the sample. One comment may have multiple codes because multiple concepts are discussed in the free-text data entry. We used the analysis of comments for the three scenarios to characterize design implications.

Semi-structured Interviews

We conducted semi-structured interviews with a convenience sample of nurses who cared for hospitalized acute care patients in our medical center. Nurses were compensated ten dollars for their time. The interview questions were related to nurses' flowsheet documentation behaviors and use of optional documentation within flowsheets. Each interview lasted between 15-30 minutes and was audio-recorded. Data were iteratively analyzed and data collection continued until data saturation was reached.

Results

Content Analysis

Our data set for this sub-analysis consisted of 201 cardiac arrest patients, for whom 3,341 oxygen level measurements, 986 blood sugar measurements, and 4,272 blood pressure measurements were documented in the EHR. There were 350 comments associated with these measurements: 168 were associated with oxygen level, 77 were associated with blood sugar, and 105 were associated with blood pressure.

Some comments included multiple concepts and were categorized as having multiple codes. Inter-coder reliability on 10% (n=35) of the sample was 89%. Table 1 shows the coding by comment category [6]. One-hundred and fifty of the 168 (89%) oxygen level comments indicated information about the supplemental oxygen that was administered, despite the availability of a structured field for that data type on a different flowsheet. For example, one comment stated: "After am [morning] care with Chest PT and oral suctioning, patient SaO2 sat remains 92-93 when previously 96%, MD made aware, increase FiO2 to 50% per MD Smith." In non-medical terms this comment means: "After providing care to the patient in the morning and removing the secretions from his lungs and mouth that he cannot cough up on his own because he is sedated and on a mechanical ventilator, the patient's oxygen level dropped and remained low between 92-93%. I [the nurse] called the doctor and we increased the amount of supplemental oxygen the patient was receiving to 50%." It is clear that the time-dependent intervention information (after am morning care) and the contextualizing assessment information (SaO2 remains 92-93% when previously 96%) expressed in this comment could not be expressed in one structured data field; however, the association with the structured data entry is important for clinical interpretation. For instance, for a normal oxygen level, the intervention comment "room air" indicates that the patient has an excellent respiratory status and does not need any supplemental oxygen, while "100% Non-Rebreather" indicates that the patient is significantly unstable and needs the greatest amount of oxygen that can be provided without mechanical ventilation to maintain a normal oxygen level. That high level of oxygen is supplied through a face mask referred to as a 100% Non-Rebreather. See table 2 for additional examples of the information contained in comments that impact clinical interpretation of structured data points.

Table 1. Categories of Information Found in Nurses' Comments

Categories of Information Found in Nurses' Comments[6]	Oxygen Level N (%)	Blood Sugar N (%)	Blood Pressure N (%)
Intervention	150 (73.2)	36 (35.7)	36 (20.8)
MD/NP/PA was aware	29 (14)	34 (33.7)	69 (40)
Assessment	18 (8.8)	14 (13.9)	28 (16.1)
Equipment information	2 (1)	0 (0)	12 (6.9)
Plan	3 (1.5)	3 (2.9)	13 (7.5)
Reference to other shift or location	1 (0.5)	5 (4.9)	4 (2.3)
RN aware	1 (0.5)	9 (8.9)	10 (5.8)
Reference to other documentation	1 (0.5)	0 (0)	1 (0.6)
Total	205[‡]	101[‡]	173[‡]

[‡]Totals greater than number of comments because comment may have more than one concept and, therefore, more than one code[6]

Another comment associated with oxygen level was: "[oxygen monitor] placed on forehead and ear, unable to get level denies sob (short of breath)". The structured data field for the oxygen level was empty and this comment explains that the oxygen level was missing on the flowsheet because the monitor was unable to detect an oxygen level (which may occur in some patients that have poor circulation). The nurse included additional assessment information that the patient was not short of breath to indicate that the patient was stable.

Table 2. Examples of information contained in comments that impact clinical interpretation

Sp02[±]	Comment	Possible Clinical Interpretation*
96	"2 Liters nasal cannula"	Patient is requiring the minimal level of oxygen supplementation. Patient is stable.
100	"28% trach collar"	Minimal oxygen setting for a tracheostomy collar. Patient is stable, but airway remains at risk.
95	"ETT size # 8, lip line 22.5 cm, P/S 7, Vt 500, FiO2 40%, peep 5, pt volume 300-400"	Minimal ventilator settings. Patient is likely stable and may be ready for extubation.
100	"Orally intubated AC 12 TV500 FIO2 100% PEEP 5. ETT tube 6.5, 24cm at the lip."	High ventilator settings. Patient may be critical but stabilized on the specified ventilator settings.
97	"-93 ra- c/o r side discomfort= rales -o2 6lnc sat 97 dr.wong made aware."	Patient is in pain with abnormal breath sounds (rales) and increasing oxygen demands. Patient is unstable.

[±]Sp02 = oxygen saturation;*Clinical interpretation is based only comments associated with normal Sp02. Additional patient data may change interpretation of the patient's clinical state.

The 36 (47%) intervention comments associated with blood sugar ranged from discussing adherence to the hospital's insulin protocol (which is also documented on a flowsheet) to follow-up assessments and actions for critically high or low blood sugar levels (normal blood sugar is 60-100 mg/dL). For example, "Insulin drip decreased by 1 unit, per protocol from 4.5 unit to 3.5 unit" and "recheck again=45, OJ given with sugar, sugar rechecked after OJ with sugar given = 47, MD informed, PRN [as needed] med given." The second comment includes time series information to show the relationship between the measurement, the intervention, the follow-up assessment, and the subsequent intervention that was necessary to stabilize the patient.

The 36 (20.8%) intervention comments associated with blood pressure contextualized and discussed the time-course of events related to the measurement. For example: "Started 500cc Normal Saline bolus at this time, patient remains

awake, 6pm 500cc Normal Saline bolus completed at this time, blood pressure 120/54", and "Unable to get blood pressure reading through machine, manually and even palpatory, gave Norepinephrine wide open." In the second example, no blood pressure measurement was recorded because the patient's blood pressure was too low to be detected; therefore, the nurse administered an intravenous drug at the maximum dose to raise the blood pressure.

Semi-structured Interviews

Five acute care nurses were interviewed. All of the nurses were female, had an average of 13 years of clinical experience (range: 7 – 31 years), and had used the EHR at our medical center for at least 4 years. Four of the nurses had a Bachelor of Science degree in Nursing and 1 had a diploma from a nursing program. Four of the 5 nurses reported being very comfortable using a computer and retrieving clinical information electronically. One nurse reported being very uncomfortable using a computer and retrieving clinical information electronically.

All of the nurses stated that they documented optional comments in EHR flowsheets. Four of the 5 nurses perceived comments as an effective method of communication with physicians. The other nurse indicated that she did not believe the EHR comments were a good way to communicate information; she preferred to enter a nursing note to communicate information. Two themes emerged from the interview data related to comments: 1) Convenience of entering documentation and 2) Use of optional comments to communicate clinically significant events. The nurses liked the ability to document directly in the EHR flowsheet module because it made documentation fast and comments were clearly associated with a particular time and vital sign measurement. One nurse stated, "It is nice to be able to document a comment in the moment, right on the flowsheet, because you get busy." The nurses agreed that the presence of an asterisk, which indicated a comment had been entered, immediately communicated that there was an abnormal or unstable vital sign recording at the specified time, and that an action may have been taken by the nurse as a result of the abnormality. One nurse stated that when a patient is unstable: "I document a comment and call the doctor." All of the nurses agreed that the documentation of a comment that stated they notified the doctor of the event "covers them legally". Each of the nurses indicated that the main purpose for documenting comments was not for legal purposes, but to ensure patient safety through clear communication. The nurses expected that doctors and other care team members working during subsequent shifts would see a comment and know to look for a nursing note that provided details about a specific event. One nurse pointed out that "there are a lot of people on the team.…Only one doctor gets the page [notification], but everyone can see these events highlighted [on the flowsheet]." The extra effort to document an optional comment was perceived as worthwhile because of the benefit and convenience it provided to patient care and team communication.

Discussion

Significance of Extra Nursing Effort

Because the EHR provided no way to link flowsheet data to clinical events, we considered entry of optional free-text comments to be a documentation workaround. Workarounds have been studied in EHRs and are typically described as short-cuts to save clinicians time; for instance, performing all data entry at the end of a shift.[5] The documentation of comments observed in our study was a workaround that required extra effort by nurses because it was optional and not required documentation. However, the documentation of comments were perceived as useful and convenient by the nurses because it allowed them to document directly on the flowsheet at the time of the event – the place for most of the required documentation by nurses. The theme that "the presence communicates a significant and abnormal event" confirmed our prior notion that information contained in optional comments is be perceived to be clinically important. The nurses perceived that comments, despite the extra documentation effort required, are a convenient and effective communication tool; yet, we do not know physicians' level of awareness of comments.

Efforts to Convey Temporal Relationships and Notify other Providers

The effective communication of clinical relationships and their time dependencies within the EHR is essential. Our analysis indicated that: 1) nurses utilize optional free-text comments to communicate contextual relationships and dependencies, and 2) certain types of clinical data "belong together" despite the constraints imposed by EHRs.

Intervention and assessment information constituted 59% of the comment information. Per hospital protocol, this information is documented elsewhere in the EHR in a structured format. We know that the interpretation of a physiological measurement, such as oxygen level, is dependent on interventions (such as the amount of supplemental oxygen administered) and the evaluation of the patient's response to those interventions. Historically, to aid the intervention-response interpretation, nurses annotated paper-based flowsheets with written comments to

convey "the whole picture of the patient's condition at a certain hour".[8] Within the EHR every structured field is time-stamped; however, it was not possible to view information from separate flowsheets simultaneously.

Almost 30% of comments indicated a clinician was notified. This suggests that tools to support notification (e.g., text paging, instant messaging) at the time a vital sign is documented can streamline documentation and workflow.

Design Implications

Based on our findings and a review of the literature, we suggest the following principles to inform the redesign of EHR user interfaces to improve data entry and data review in the context of the clinical scenarios studied.[9-11] Data entry within a flowsheet should: 1) Allow the user to document the events of a 'clinical episode' (e.g., oxygen level and oxygen administered) for a given point in time without changing screens, and 2) Provide communication tools to support the notification of abnormal measurements to other members of the health care team, such as physicians. Data display within a flowsheet should: 1) Convey the temporal relationship between assessment and intervention, and 2) Link evaluation of the patient's response to the intervention for a given clinical episode.

Visualization tools are useful to convey temporal relationships among data that may or may not be known to the users and may be the appropriate tool for reviewing EHR flowsheet data.[9,11] There is minimal research that discusses visualization tools to support, at the time of data entry, a user's desire to convey known temporal or clinical relationships (e.g., "the sugar was rechecked after OJ with sugar was given and it was 47"). There are many challenges to implementing computer supported cooperative work (CSCW) tools within healthcare[10]; however, the association between structured data and a nurse's documentation that a clinician was notified may provide insight into the appropriate time and place to incorporate communication and coordination tools within the EHR.

Limitations

The limitations of this study were the single hospital setting from which data were collected. However, the triangulation of the content analysis of the EHR flowsheet data and the interviews with acute care nurses increases confidence in the discussed themes and conclusions drawn from this study.

Conclusion

We found that EHR flowsheet design was sub-optimal to support documentation for three clinical scenarios as evidenced by nurses' use of workarounds that require extra effort. The workarounds were employed to convey clinically significant relationships not otherwise linked in the EHR data entry or review screens. The design of EHRs should be improved to support data entry and review of clinical information that naturally belongs together.

Acknowledgments

References

1. National Research Council. *Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions*. Washington, D.C. 2009.
2. Fontaine BRM, Speedie SP, Abelson DM, Wold C. A Work-Sampling Tool to Measure the Effect of Electronic Medical Record Implementation on Health Care Workers. *Journal of Ambulatory Care Management*. 2000.
3. Ammenwerth E, Spötl H-P. The time needed for clinical documentation versus direct patient care. *Methods of Information in Medicine*. 2009;48(1):84-91.
4. Cottrell C. Medicare data study spotlights coding errors. *J AHIMA*. 2000;71(8):58-59.
5. Collins SA, Bakken S, Vawdrey DK, Coiera E, Currie LM. Discuss now , document Later : CIS/CPOE Perceived to be a " Shift Behind " in the ICU. In: *Proceedings of the 13th World Congress on Medical Informatics: Medinfo 2010.*; 2010:178-182.
6. Collins SA, Vawdrey DK. "Reading between the lines" of flowsheet data: Nurses' optional documentation associated with cardiac arrest outcomes. *Applied Nursing Research*. 2011;in press.
7. Coiera E. When conversation is better than computation. *Journal of the American Medical Informatics Association*. 2000;7(3):277-86.
8. Gurman G, Steiner Z, Kriemerman S. A new intensive care worksheet. *International Journal of Clinical Monitoring and Computing*. 1988;5(1):27-30.
9. Reddy M, Dourish P. A finger on the pulse. In: *Proceedings CSCW 2002.*; 2002:344-353.
10. Bardram J, Bossen C. A web of coordinative artifacts: collaborative work at a hospital ward. In: *Proceedings of the 2005 international ACM SIGGROUP Conference on Supporting Group Work.*; 2005:168-176.
11. Plaisant C, Mushlin R, Snyder A, et al. LifeLines: using visualization to enhance navigation and analysis of patient records. In: *AMIA Annual Symposium Proceedings.*; 1998:76-80.